FEEDING AND GROWTH OF SEASONAL COHORTS OF LARVAL WALLEYE POLLOCK (THERAGRA CHALCOGRAMMA) IN AUKE BAY, ALASKA

by

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A

THESIS

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By

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ABSTRACT

Larval walleye pollock, Theragra chalcogramma (Pallas), typically occur in the water column in synchrony with peak densities of prey. A primary objective of this investigation was to examine and compare growth rates of larval pollock. The growth rate of a synchronous cohort (hatched 10-14 May, 1986) was found to be significantly higher ($P<0.05$) than that of an earlier cohort (hatched 15-19 April, 1986). Synchronous cohorts are larvae that occur simultaneously with the maximum densities of herbivorous copepods. Growth rates were determined by otolith analysis.

Prey densities and water temperature were implicated as causes of the observed differences in growth. Prey densities were approximately 3 times higher for the synchronous cohort than the early cohort. Additionally, the early cohort experienced water temperatures 2-3°C colder than the synchronous cohort. Results suggest that synchronous larval walleye pollock have higher growth rates and may have higher survival rates.

ACKNOWLEDGEMENTS

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I am particularly thankful to my wife, Rebecca Goodman, for her support and encouragement during the period I worked on my degree.

I dedicate this thesis to my parents; their inspiration and interest was unfailing.

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INTRODUCTION

Auke Bay is a typical subarctic marine ecosystem with a brief spring phytoplankton bloom that initiates a spring production cycle. One of the most important aspects of the subarctic production cycle is the herbivorous copepod maximum (Smetacek et al. 1984) when peak densities of copepod nauplii provide an optimum foraging environment for larval fishes. If they are to grow, fish larvae must occur when suitable densities of the appropriate prey are present. Low mortality rates may be experienced by larval fish foraging in an optimal prey environment, thereby enhancing recruitment to post-metamorphic juvenile populations.

Feeding success in the period immediately following hatching and yolk-sac absorption is considered critical for survival of larval fish. The importance of this first feeding interval was originally described in Hjort's (1914) critical period hypothesis. Since then other researchers have expanded the concept. Cushing (1975) proposed the match-mismatch hypothesis in which the magnitude of recruitment is linked to the match or mismatch of the production of larvae compared to the abundance of prey items.

Disturbance of food aggregations may also affect survival of larvae. Lasker (1978) proposed the stable ocean hypothesis which states that year-class recruitment is affected by higher mortality rates of larval fish if food aggregations are disturbed by storm events. The stable ocean hypothesis stresses the importance of spatial variation, especially vertical stratification.

Haldorson et al. (1987) defined four different reproductive strategies associated with the marine larval fish of Auke Bay. These strategies describe the timing of the larval fish hatching, relative to the peak abundance of copepod production. Reproductive strategies are identified as early, extended, synchronous or late. In a synchronous species, larvae occur simultaneously with maximum densities of herbivorous copepods. Synchronous species are most likely affected by fluctuations in timing of the spring phytoplankton bloom. Pollock larvae were categorized as a synchronous species (Haldorson et al. 1987).

The recruitment of larval pollock could be affected by densities of herbivorous copepods. Krieger (1985) found that the occurrence of walleye pollock

larvae in Auke Bay coincided with the highest densities of Pseudocalanus copepodids. The production of larval pollock may be enhanced and could depend upon hatching at the same time as the herbivorous copepod maximum.

My thesis objective is to determine whether or not pollock larvae that occur prior to the maximum density of copepods experience reduced growth rates. This study is part of a multidisciplinary investigation on trophic dynamics and recruitment by the APPRISE (Association of Primary Production and Recruitment in a Subarctic Ecosystem) project in Auke Bay.

A gut analysis was used to compare feeding of early and synchronous cohorts in order to estimate prey consumption by larval pollock in different prey environments. The gut analysis was used to determine whether or not pollock larvae are found in densities which are too dilute to affect the abundance of prey items as Dagg et al. (1984) and Kamba (1977) suggested in their investigations.

Biology of Walleye Pollock

The walleye pollock was described by Pallas in

1811. The scientific name, Theragra chalcogramma, is derived from the Greek roots ther (beast) - agra (food) meaning "food of the beast" (referring to fur seals) and chalcos (brass) - gramma (mark) for its color (Hart 1973).

Walleye pollock have been reported to reach an age of 17 years and a maximum fork length (FL) of 90 cm. In the eastern Bering Sea 50% of the male pollock are mature at 31 cm FL while 50% of the females mature at 33-34 cm FL. Most of the pollock biomass occurs over bottom depths of 100-300 meters (Smith 1981). Pollock have a demersal behavior and tend to form schools near the bottom during the daytime and disperse into the water column at night. Sexually mature pollock move higher, forming dense midwater layers. The pelagic eggs (≈1.5 mm diameter) disperse in the water column after spawning occurs.

The majority of spawning has been shown to occur during March and April in the Gulf of Alaska and from April to mid-May in the Eastern Bering Sea. Initially, eggs float to the surface then gradually sink to a depth of approximately 20 m where they hatch (Nishiyama and Haryu 1981).

The incubation time from fertilization to hatching varies according to temperature. Incubation time for larval pollock was found to be 26 to 27 days at 2°C (Hamai et al. 1971). In a lab study Bailey and Stehr (1986) found larval pollock hatch 13-16 days after fertilization at water temperatures of 5.6°C. Larval pollock hatch at temperatures of 3-6°C in the southeastern Bering Sea (Walline 1985).

Newly hatched yolk-sac larvae are approximately 3.5-4.0 mm long. Pollock larvae attain a length of 5.0-5.5 mm during the yolk-sac stage (Hamai et al. 1974). Larval pollock begin feeding at 4-5 days and their yolk-sac is fully absorbed after 6-7 days.

Walleye pollock larvae were found to reach metamorphosis at 22 mm SL (Standard Length). At metamorphosis pollock larvae have been shown to shift to a more demersal habitat and select different prey items (Haryu, 1980). The average time to metamorphosis was ≈56 days (Bailey and Stehr 1986).

The life history of juvenile and adult pollock has been fairly well documented in the eastern Bering Sea and northern Pacific Ocean. However, a paucity of in situ studies has been conducted on the effect of the

environment on the growth, distribution and year-class strength of the early life stages of larval pollock.

Pollock larvae are able to survive and grow in low concentrations of prey items compared to other fishes because pollock are efficient feeders, do not require high concentrations of food and are adapted to surviving in areas of impoverished food supply (Clarke 1984).

Commercial Importance

According to NPFMC (North Pacific Fishery Management Council), commercial groundfish catches landed and processed off Alaska's coasts reached 1,773,351 mt (metric tons) during 1987. The total commercial pollock catch consisted of 1,252,473 mt, or 71% of the total catch of all groundfish. These commercial fisheries include the landings of domestic, joint and foreign fisheries. Domestic groundfish caught and processed in all areas of Alaska reached 386,270 mt during 1987. The total domestic pollock catch for 1987 consisted of 244,171 mt, 63% of the total. In comparison, the total domestic harvest for 1986 totaled

139,859 mt (Janet Smoker, NMFS, pers. comm.). Additionally, pollock comprised the largest biomass of any fish species captured in bottom trawl sampling from 1969 to 1981 throughout northern southeast Alaska (Carlson et al. 1982). Pollock supported the world's largest monospecific fishery during 1985 (Bailey and Stehr 1986).

Distribution

Pollock are found from central California north to the Chukchi Sea, and from the Gulf of Anadyr to the southern Sea of Japan (Hart 1973; Wolotira et al. 1977). Walleye pollock are abundant throughout southeastern Alaska, although not in the extensive quantities found in the Gulf of Alaska and the Bering Sea.

MATERIALS AND METHODS

Field Collections

All field samples were collected from the R.V. Maybeso with a 1.0 m^2 NIO Tucker trawl equipped with a 505 μm mesh net. The trawl was towed through the water column to depths of 35 m in a double oblique trajectory. A flow meter (General Oceanics model 2030) attached within the entrance of the net was used to calculate the volume of water filtered.

Trawl samples were collected along a transect line adjacent to the ABM (Auke Bay Monitor) buoy. The ABM is used as a standard reference point for all components of the APPRISE project (Figure 1). A total of 323 plankton tows were collected on 26 sampling dates in 1986 (Table 1).

Otolith Analysis Samples

For otolith analysis ten replicates were collected twice weekly from April 22 until July 18th (Table 1).

Table 1. Sampling schedule for the 1986 season.

SAMPLING DATE	NUMBER OF FORMALIN REPLICATES	NUMBER OF ALCOHOL REPLICATES
4/1	8	
4/22	5	10
4/25		10
4/28	5	10
5/2		10
5/5	5	10
5/9		10
5/12	5	10
5/16		10
5/19	5	10
5/23		10
5/26	5	10
5/30		10
6/2	5	10
6/6		10
6/9	5	10
6/13		10
6/16	5	10
6/20		10
6/23	5	10
6/27		10
6/30	5	10
7/8	5	10
7/9		10
7/15	5	10
7/18		10

Replicates collected on each sampling trip were immediately preserved in 90-95% denatured alcohol. A buffer of tri-sodium phosphate (Tris) and 6 M HCL was added to the alcohol to fix the pH between 7-8 to prevent deterioration of the otoliths. The otoliths in larval pollock are only slightly calcified and will dissolve in acidic environments (Radtke and Waiwood 1980). Following each field trip the alcohol was replaced in each sample to assure preservation. The samples were then stored (in the lab) until the larval pollock were removed for otolith analysis.

Gut Analysis Samples

For gut analysis of larval pollock, five replicate samples were collected once weekly from April 1-June 30, 1986 (Table 1). Replicates collected on each sampling trip were immediately preserved in a borax buffered solution of 10% formalin. Samples were returned to the lab and the pollock larvae were sorted out and stored until analyzed.

Otolith Analysis

A dissecting microscope, fitted with two polarizing filters to accentuate the otoliths, was used for measuring the larvae and removing the otoliths. Pollock larvae were measured to the nearest 0.1 mm SL. The otoliths, both sagittae and lapilli, were identified and separated from the larvae with fine tipped probes. The otoliths were then transferred to and mounted on a clean slide with clear fingernail polish.

Increments were counted on the sagittae and lapilli when the otoliths were of similar sizes. In older larvae, only the larger sagittae were examined due to the diminishing readability of the lapilli. Increments were magnified 1000X under an oil immersion lens on a Leitz Laborlux 12 compound microscope. The image was transmitted to a video camera and displayed on a 9 in. black and white monitor.

Daily growth increments were first reported by Panella (1971, 1974). Since then many researchers have used them to determine growth rates of larvae (Jones 1986; Kendall et al. 1987). Nishimura and Yamada (1984)

confirmed by scanning electron microscopy that the first increment appeared on the day of hatching and additional increments were formed on a daily basis for larval walleye pollock. Increment counts were assumed to equal one day in age (Bailey and Stehr 1986). For this investigation increments are assumed to be deposited on a daily basis and are equal to the age of the larvae in days after hatch.

Daily periodicity of increment formation has been confirmed in many marine larval fish. This method of aging larval fish can be used in fishery research to document timing and duration of spawning, to analyze major life history stages and events and to determine growth rates of larval fish during the "critical period" when recruitment may be determined.

Increments on otoliths develop when different combinations of protein, otolin, and calcium carbonate are deposited in layers (Pannella 1971). The relative differences of material form increments composed of an inner light band and an outer dark band. Each increment represents one cycle of formation referred to as the periodicity of deposition.

Two major cohorts were chosen from hatching pulses

(peaks in density) (Figure 2). The early cohort included those larvae that hatched between April 15-19 while the synchronous cohort included those fish found to have hatched from May 10-14.

To identify cohorts, all pollock larvae were first measured to the nearest 0.1 mm SL. Length frequency histograms were constructed for each sampling day. The percent frequency of larval pollock of given length during each sampling day are depicted on resulting histograms. Pollock larvae associated with the length mode of each histogram were then aged. The modal age of larvae from each hatching pulse identified the primary hatching day. A cohort was defined as those pollock larvae that hatch within ± 2 days of the primary hatching date. Growth analyses used only those larval pollock whose ages placed them in a cohort selected for study.

Growth Analysis

Growth of the pollock larvae was estimated by examining otolith microstructure (Jones 1986). Growth curves were constructed for early and synchronous cohorts. A linear regression was used to describe the

slope of the age at length data for each cohort. Walline (1983) found that a linear regression is representative for the the average growth pattern for individual pollock 5-25 mm SL. Differences in growth between cohorts were quantified by comparing growth curves and examining the length at age of both cohorts. The growth rates of the cohorts were compared using a modified Student's t test as described by Zar (1974).

Gut Analysis

Two feeding groups representing the early and the synchrononous cohorts were analyzed in order to quantify and compare prey consumption. The early feeding group consisted of those larvae that appeared in the water column at the same time as the early cohort (April 22-May 12). The synchronous feeding group was comprised of those larvae present in the water column with the synchronous cohort (May 19-June 30).

Larval pollock of both feeding groups were divided into four length categories for subsequent statistical analyses: <5.5 mm, 5.5-6.9 mm, 7.0-9.9 mm and >=10 mm. These categories were selected to show the shift in

prey composition as the larval pollock grow. Statistical tests were confined to the first two larval length groups due to the small sample size in the early cohort of length groups larger than 7 mm.

For the various length categories, percent number (%N), percent volume (%V), and percent frequency of occurrence (%FO) of prey were tabulated. The %N is the the percentage of total number of prey items; %V is the percentage of total volume of prey items; %FO is the percent frequency of occurrence of pollock larvae that contain a particular prey item.

Larval pollock were measured to within 0.1 mm prior to stomach dissection. Wet weights of all pollock, preserved in formalin, were measured in mg (milligrams) using a Cahn electrobalance. Prey were identified to the lowest possible taxon and measured to within ± 10 μm (SL). Lengths and the greatest widths were measured for all food items in the larval stomachs. Carapace lengths were taken for nauplii and prosomal lengths were measured for the copepodites and adult copepods. Volume was calculated using the equation for a spheroid, indicated as

$1/6\ [\ \pi(\text{length})(\text{width})^2\ ]$ (Gadomski and Boehlert 1984).

Wet weights of larval pollock and Fulton's condition factor were used to compare the "well being" of the larval fish. Fulton's condition factor is based on the hypothesis that heavier fish of a given length are in better condition. Condition factor (K) is calculated from:

$$K = \frac{100\ (W)}{(L)^3}$$

where;

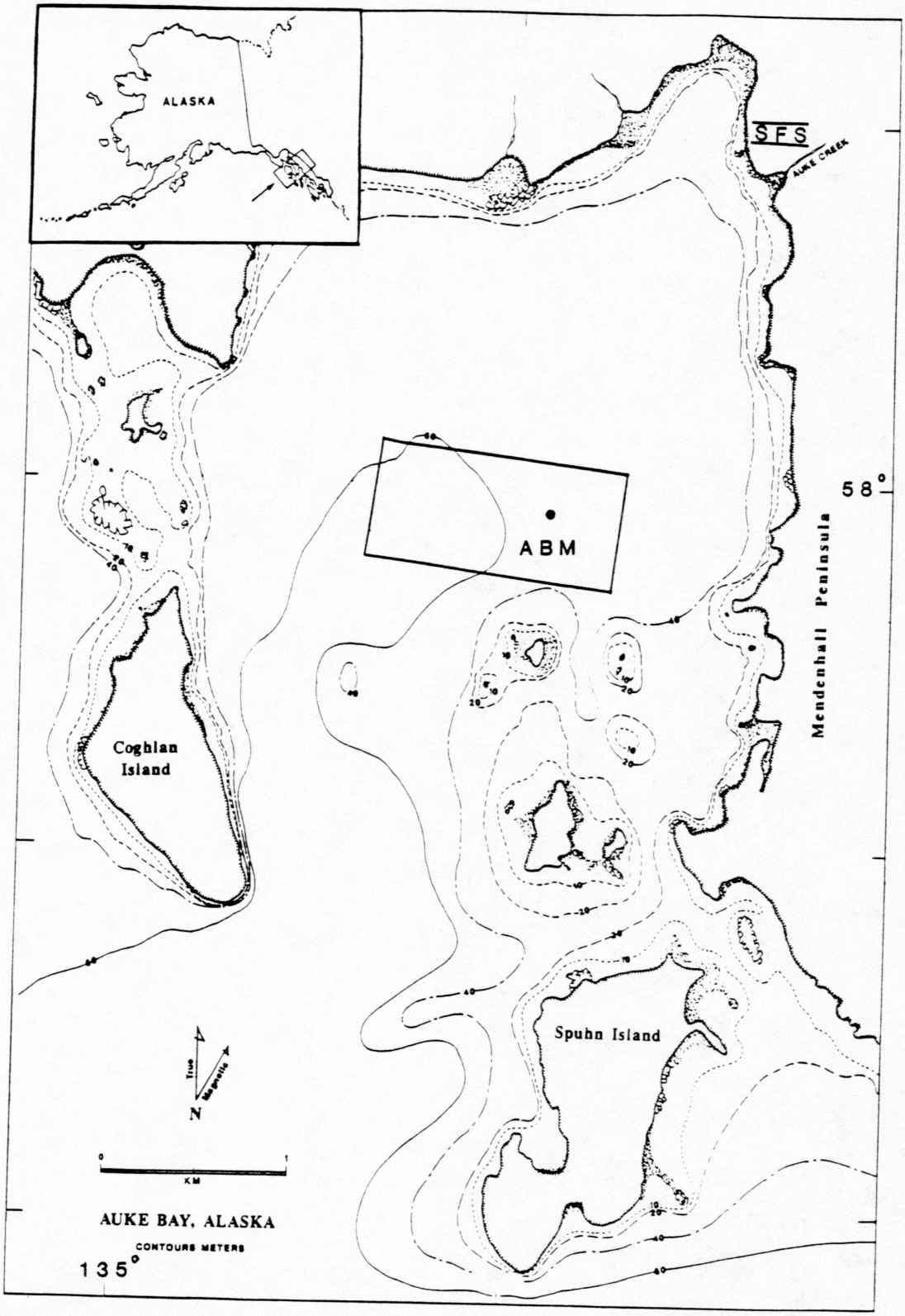
(W) = wet weight in mg (milligrams)
(L) = SL in millimeters

Statistical analyses were conducted with Statgraphics software (Statistical Graphics Corp., 1986). To test for departures from normality, standardized tests for skewness, kurtosis and normal probability plots were examined. Parametric and nonparametric one-way ANOVAS's were used where appropriate. Dispersion of data around means was described using ± one standard error (SE). All statistical tests were considered significant when $P<0.05$ and highly significant when $P<0.01$.

Study Area

Auke Bay is located at latitude 58°22'N and longitude 134°40'W in north Stephens Passage 19.3 km northwest of Juneau, Alaska (Figure 1). Auke Bay covers an area of about 11 km^2 and contains several small islands and reefs (Krieger 1985). The bottom topography of Auke Bay is somewhat irregular and is composed primarly of cobbles, broken shell, fine sand, silt and clay. Depths range from 95 m in a submarine trench on the south-east side of Coghlan Island to approximately 40 m over most of the bottom of the bay. Auke Bay is relatively isolated from wind-generated circulation patterns often present in the main passages and straits, but is influenced to some extent by tidal advection. Surface water temperatures range from <2°C between January and March to 17°C in August. Vertical temperature profiles have been shown to change from nearly uniform in winter to strongly stratified in summer (Bruce *et al*. 1977).

Figure 1. Geographic location of study area in Auke Bay in relation to the ABM (Auke Bay Monitor).


ALASKA
SFS
AUKE CREEK
ABM
58°
Mendenhall Peninsula
Coghlan Island
Spuhn Island
True
Magnetic
N
0
1
KM
AUKE BAY, ALASKA
CONTOURS METERS
135°

RESULTS

Abundance and Size Distribution

Larval pollock were present in the water column at densities of 0.23 larvae/m^2 of surface area when sampling began (Figure 2). The early cohort appeared as a pulse of larvae around April 22 and reached a peak mean density of 0.48 larvae/m^2. The peak mean density of the season, associated with the synchronous cohort, was 14.6 larvae/m^2 of surface area. A pulse of pollock larvae occurring June 23 reached a mean density of 1.1 larvae/m^2.

The size distribution of larval pollock over time is indicated by length frequency histograms. An increase in size of pollock larvae occurred as the season progressed (Figures 3-7). A modal histobar occurred for larvae between 5.0-6.0 mm in length in the length frequency histogram for April 22 (Figure 3). I determined, using otolith analysis, that the larvae associated with the April 22 mode hatched April 17 ± 2 days. Therefore, the early cohort consisted of larval

Figure 2. Mean densities of larval walleye pollock (in numbers/square meters of surface) at the Auke Bay Monitor from April 1 until July 15, 1986. Standard error bars show the variance of data around the mean.

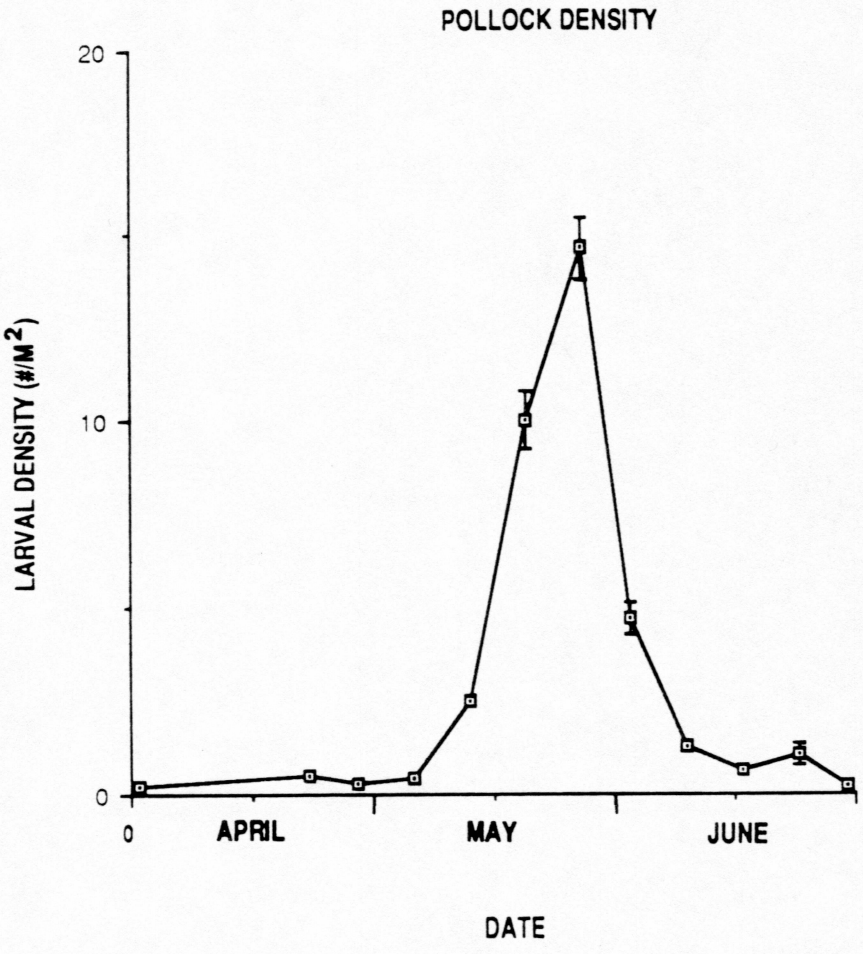

POLLOCK DENSITY
20
10
0
LARVAL DENSITY (#/M2)
0
APRIL
MAY
JUNE
DATE

Figure 3. Length frequency distributions (by 1.0 mm size groups) of larval walleye pollock collected at Auke Bay Monitor from April 22 to May 2, 1986.

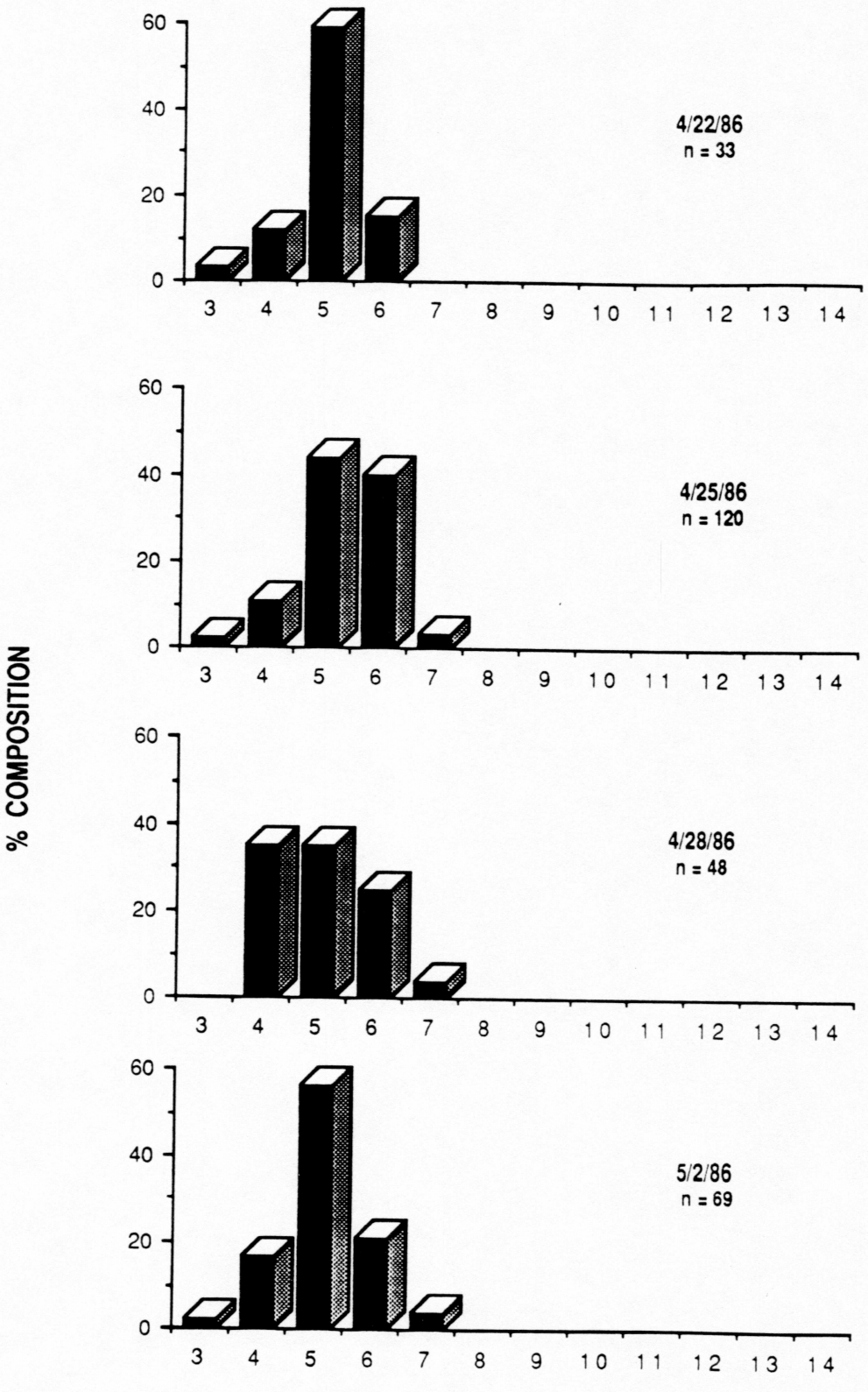

% COMPOSITION
60
40
20
0
3 4 5 6 7 8 9 10 11 12 13 14
4/22/86
n = 33
4/25/86
n = 120
4/28/86
n = 48
5/2/86
n = 69
LENGTH (mm)

Figure 4. Length frequency distributions (by 1.0 mm size groups) of larval walleye pollock collected at Auke Bay Monitor from May 5 to May 15, 1986.

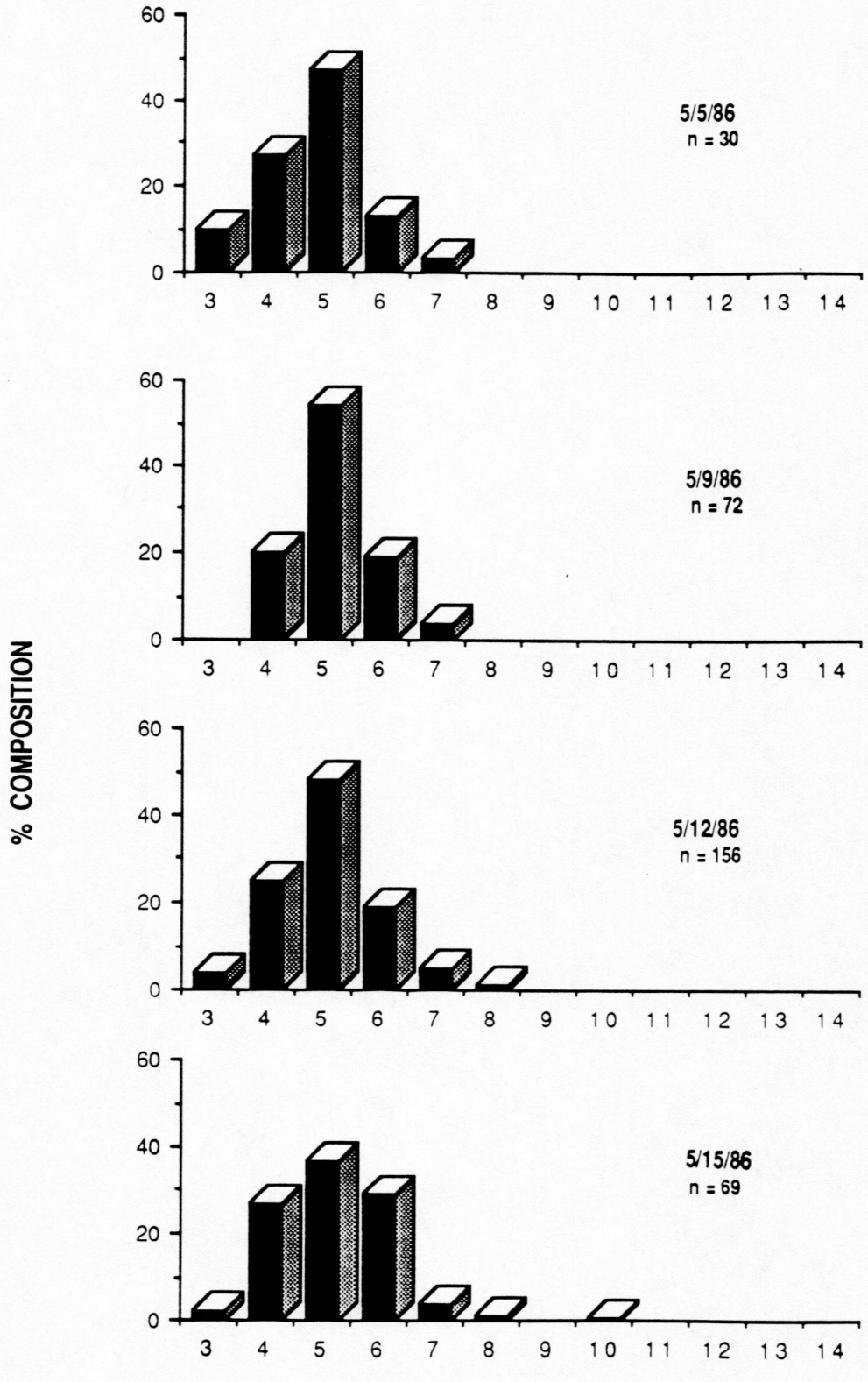

% COMPOSITION
60
40
20
0
3 4 5 6 7 8 9 10 11 12 13 14
5/5/86
n = 30
5/9/86
n = 72
5/12/86
n = 156
5/15/86
n = 69
LENGTH (mm)

Figure 5. Length frequency distributions (by 1.0 mm size groups) of larval walleye pollock collected at Auke Bay Monitor from May 19 to May 30, 1986.

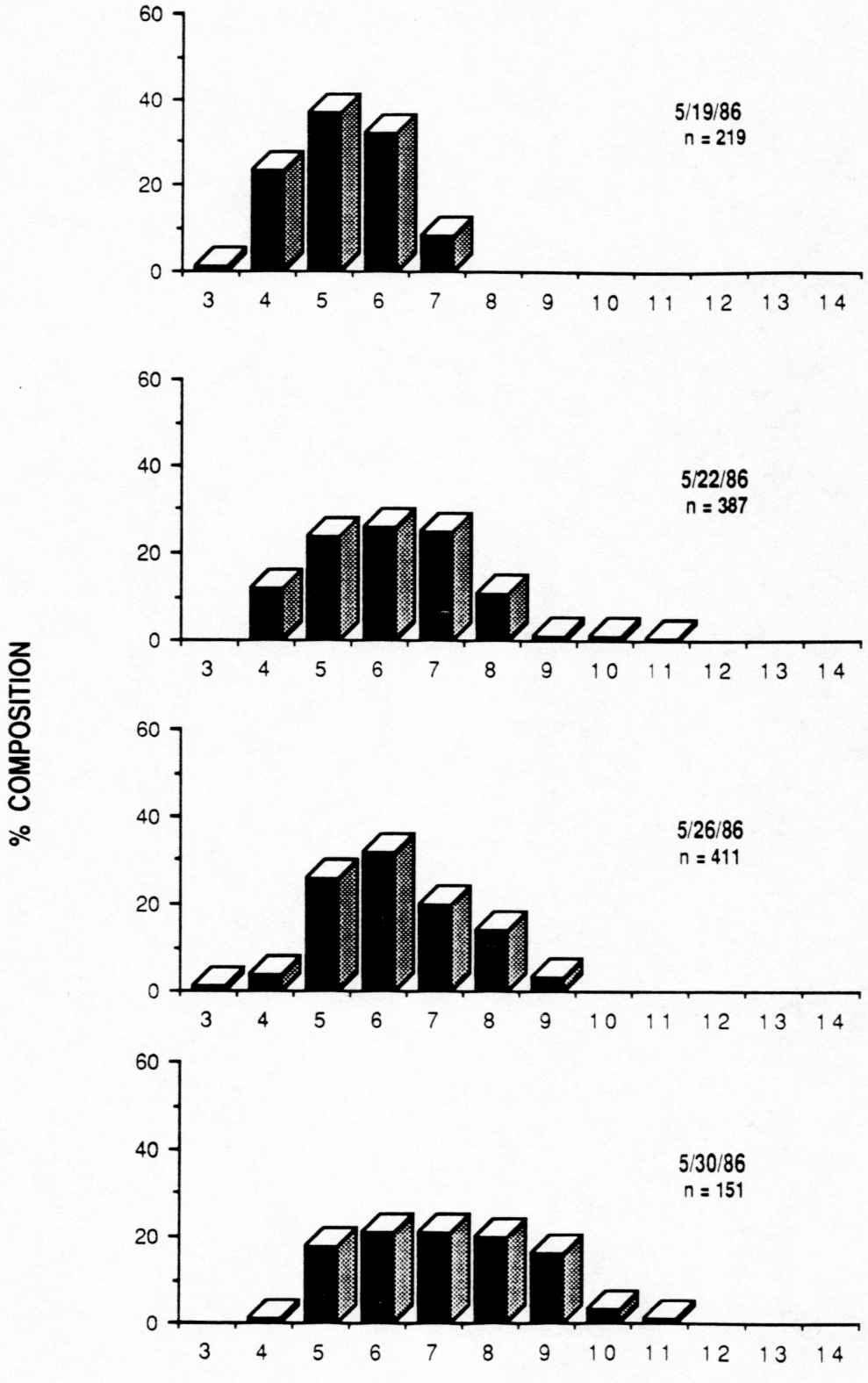

% COMPOSITION
60
40
20
0
3 4 5 6 7 8 9 10 11 12 13 14
5/19/86
n = 219
5/22/86
n = 387
5/26/86
n = 411
5/30/86
n = 151
LENGTH (mm)

Figure 6. Length frequency distributions (by 1.0 mm size groups) of larval walleye pollock collected at Auke Bay Monitor from June 2 to June 13, 1986.

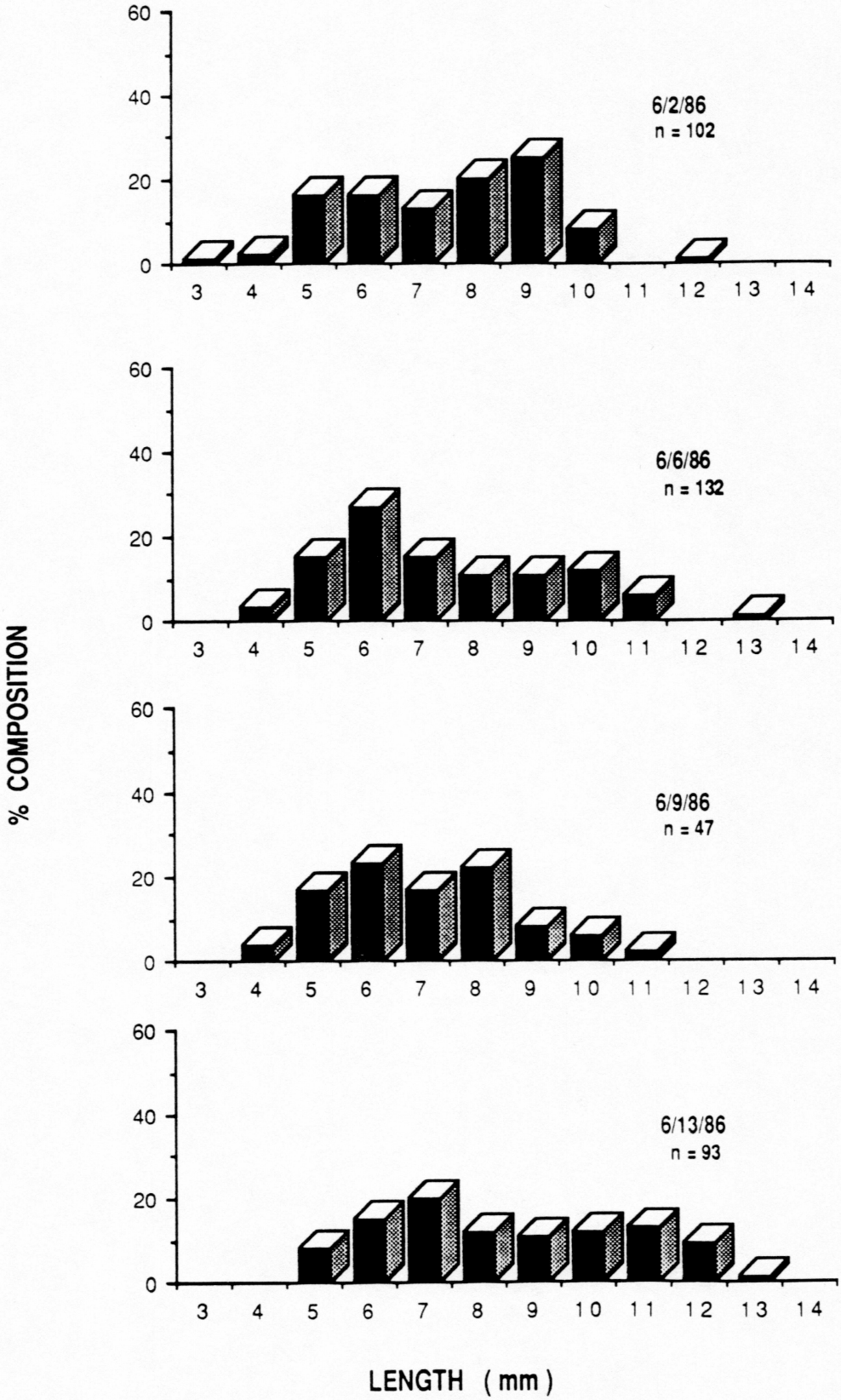
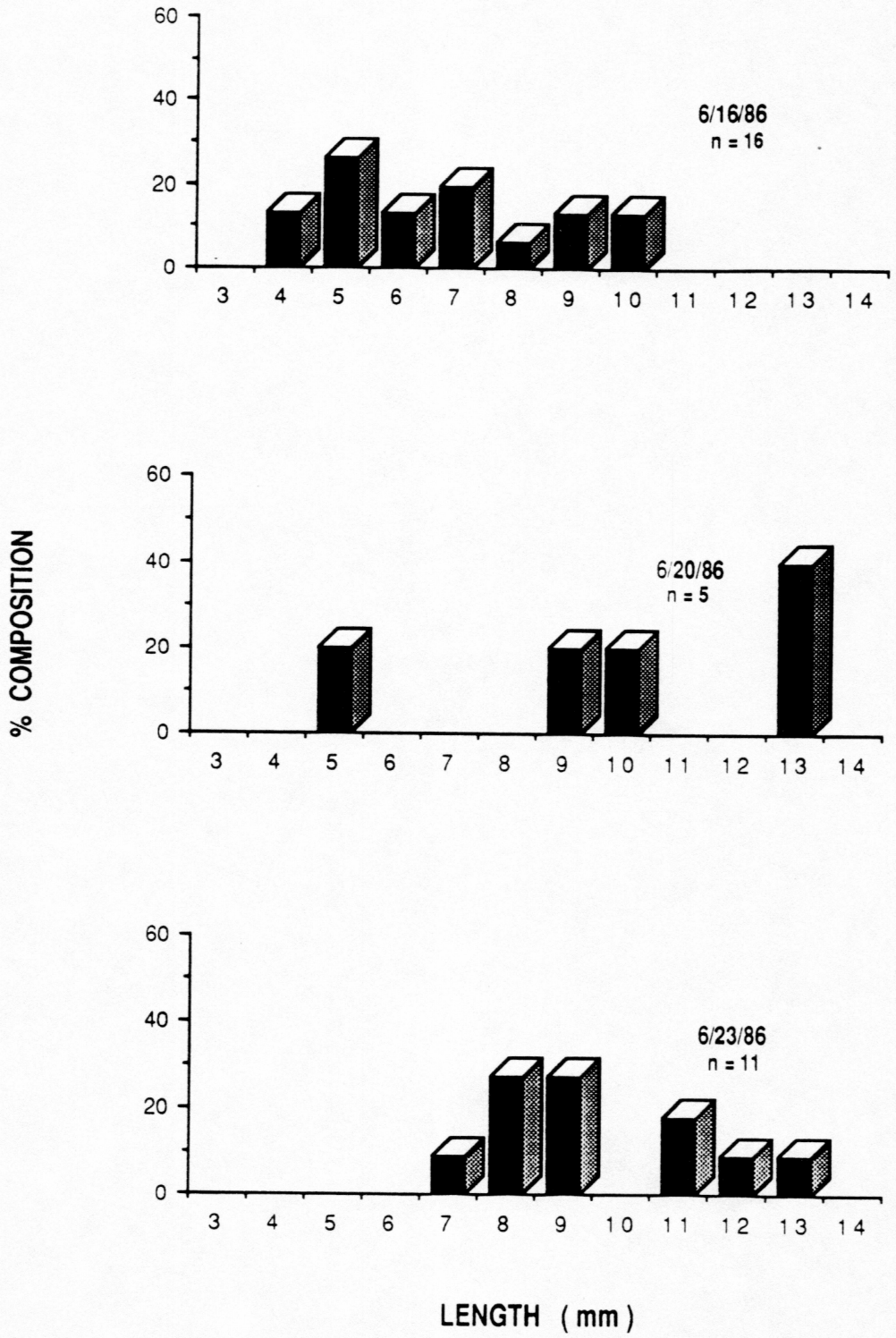

% COMPOSITION
60
40
20
0
3 4 5 6 7 8 9 10 11 12 13 14
6/2/86
n = 102
6/6/86
n = 132
6/9/86
n = 47
6/13/86
n = 93
LENGTH (mm)

Figure 7. Length frequency distributions (by 1.0 mm size groups) of larval walleye pollock collected at Auke Bay Monitor from June 16 to June 23, 1986.


% COMPOSITION
60
40
20
0
3 4 5 6 7 8 9 10 11 12 13 14
6/16/86
n = 16
6/20/86
n = 5
6/23/86
n = 11
LENGTH (mm)

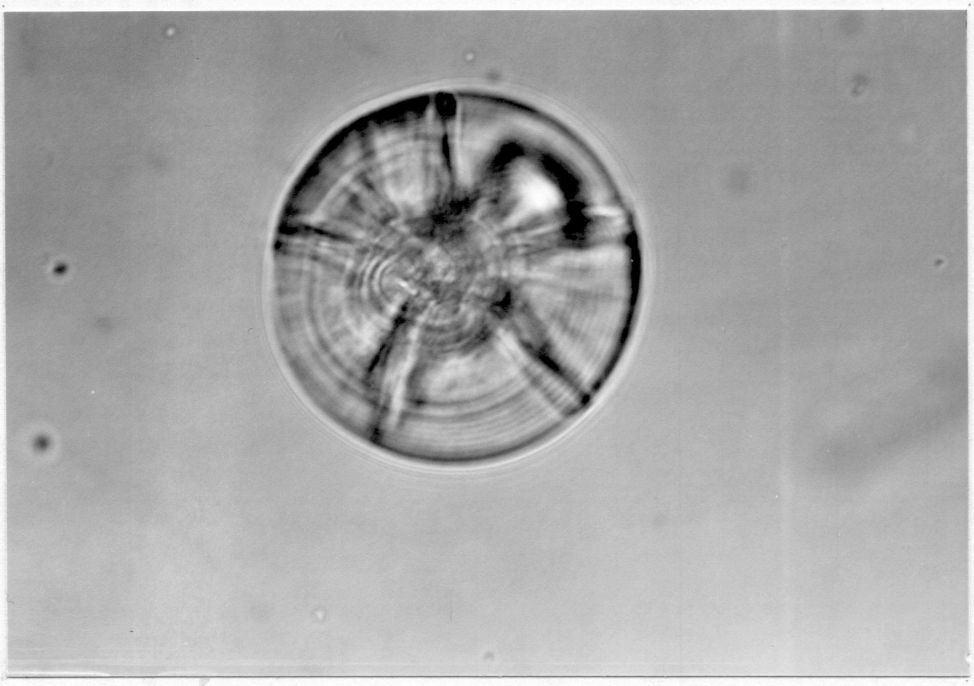
pollock hatching mostly in the period April 15-19. In subsequent sampling days the cohort can be followed by examining the shift in modal length frequency distributions. The primary hatching day for the synchronous cohort was determined to be May 12. Therefore, larval pollock hatching May 10-14 were considered members of the synchronous cohort. Length frequencies associated with the pulse of pollock occurring June 23 could not be followed because their densities diminished in subsequent sampling trips.

Growth Analysis

The otoliths of 309 larval walleye pollock were analyzed for age assessment (Figure 8). Ages were determined for 235 (76%) of these fish, including 35 larvae hatched in the early cohort and 69 larvae hatched in the synchronous cohort. Standard lengths ranged from 4.1 mm to 14.2 mm and the incremental counts (days in age) ranged from 4 to 44 days.

Growth rates for both cohorts were estimated using a linear regression. The early (n=35) and synchronous (n=69) cohorts had respective growth rates of 0.171

Figure 8. Otolith from a 7.5 mm SL larval walleye pollock with 16 daily growth increments.



mm/day (Figure 9) and 0.235 mm/day (Figure 10). The growth rates of the early and synchronous cohorts were significantly different when compared by a modified student's t-test ($P<0.05$) (Figure 11).

Additionally, a linear regression was used to compare the growth rates of the early and synchronous cohorts of larval pollock <15 days in age and <20 days in age. A significant difference in growth rates, using the student's t-test, existed between cohorts for larvae <15 days (Figure 12) and larvae <20 days (Figure 13).

Gut Analysis

Length categories of larval pollock from the early cohort were identical to corresponding length categories in the synchronous cohort. Mean lengths of larval pollock in categories <5.5 mm; 5.5-6.9 mm; and 7.0-10.0 mm were 5.1, 6.0, and 7.5 mm for the early cohort and 4.9, 6.1 and 8.1 mm for the synchronous cohort. In the synchronous cohort the mean length of larval pollock >10.0 mm was 11.2 mm. There were no significant differences in the mean lengths between the early and synchronous cohort for any length

Figure 9. Length-age regression for the early (hatched April 15-19) cohort of larval walleye pollock in Auke Bay during 1986.

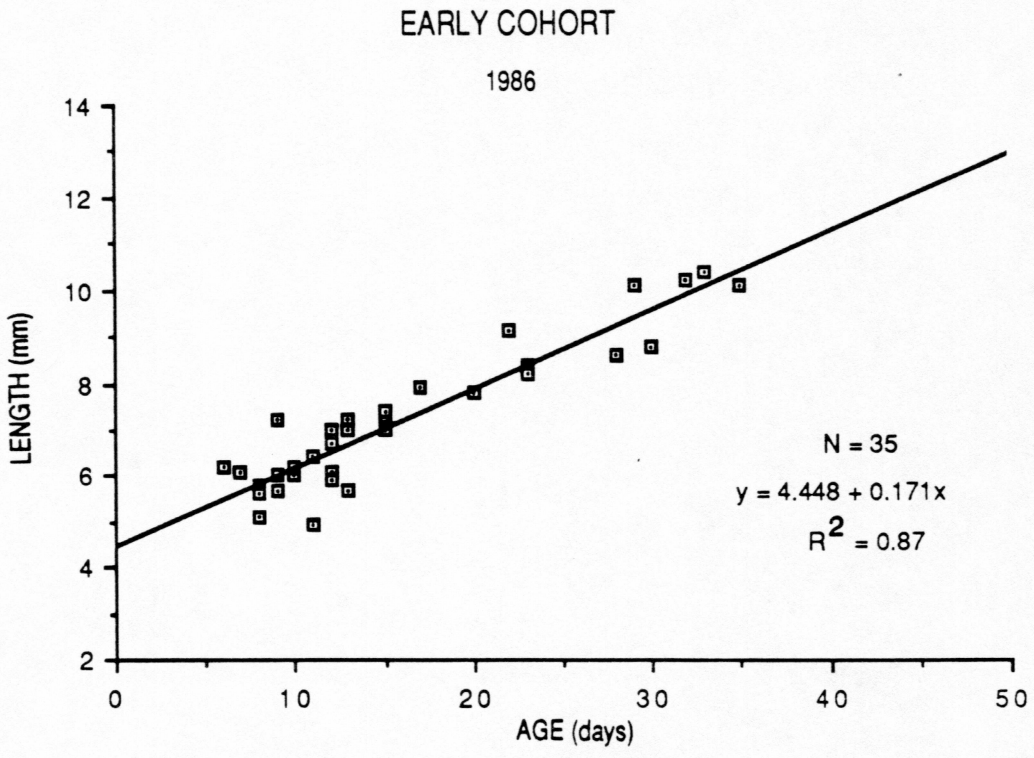

EARLY COHORT
1986
LENGTH (mm)
AGE (days)
N = 35
y = 4.448 + 0.171x
R2 = 0.87
14
12
10
8
6
4
2
0
10
20
30
40
50

Figure 10. Length-age regression for the synchronous (hatched May 10-15) cohort of larval walleye pollock in Auke Bay during 1986.

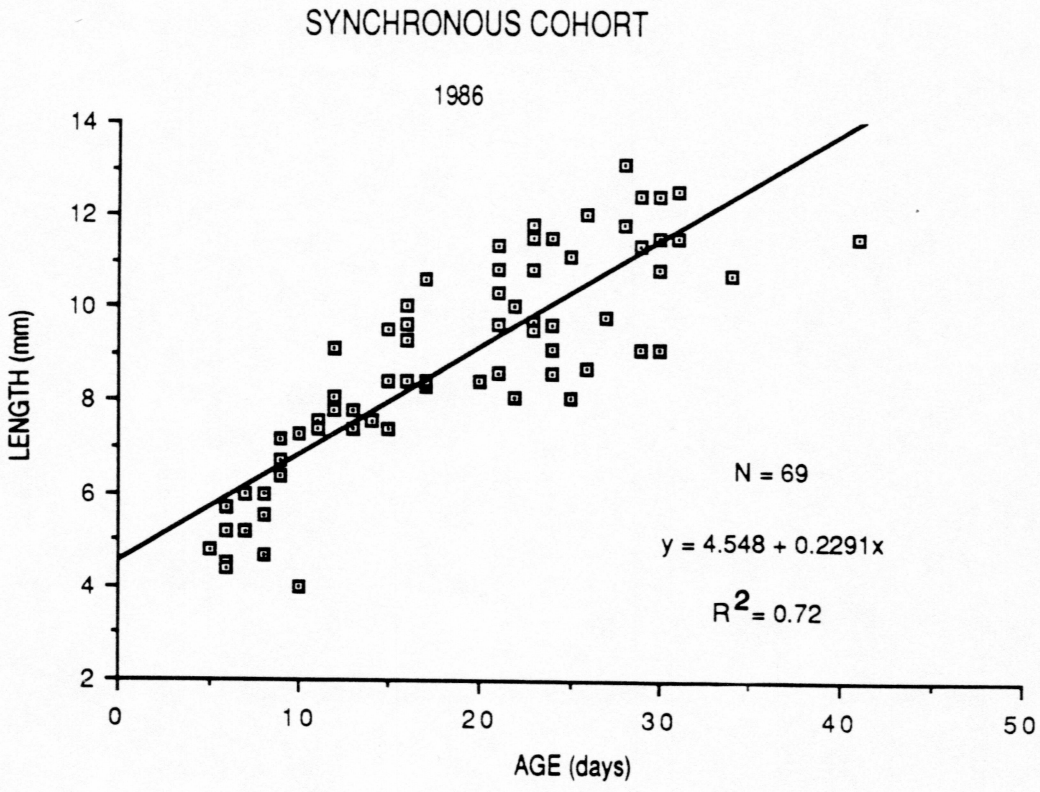

SYNCHRONOUS COHORT
1986
LENGTH (mm)
AGE (days)
N = 69
y = 4.548 + 0.2291x
R2 = 0.72
14
12
10
8
6
4
2
0
10
20
30
40
50

Figure 11. Length-age regressions for the early (hatched April 15-19) and the synchronous (hatched May 10-15) cohorts of larval walleye pollock in Auke Bay during 1986.

COMBINED COHORTS 1986

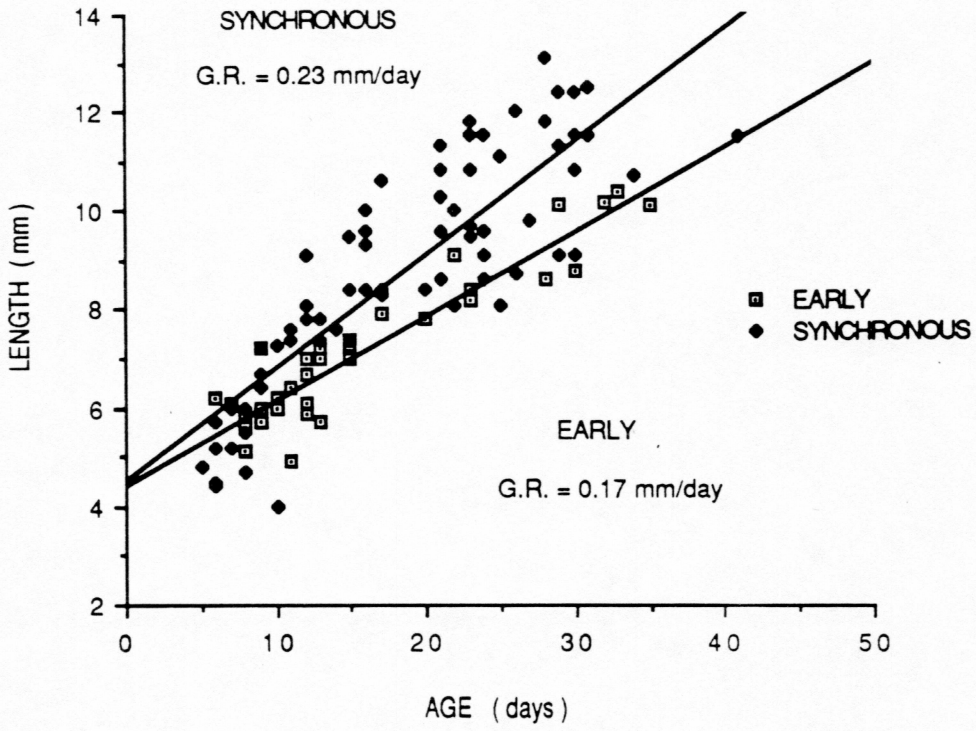


Figure 12. Length-age regressions for the early (hatched April 15-19) and the synchronous (hatched May 10-15) cohorts of larval walleye pollock <15 days in age. G.R.= growth rate. For the early cohort; n=22, R^2=0.33, y=4.57 + 0.1462 x. For the synchronous cohort; n=25, R^2=0.68, y=2.73 + 0.3937 x.

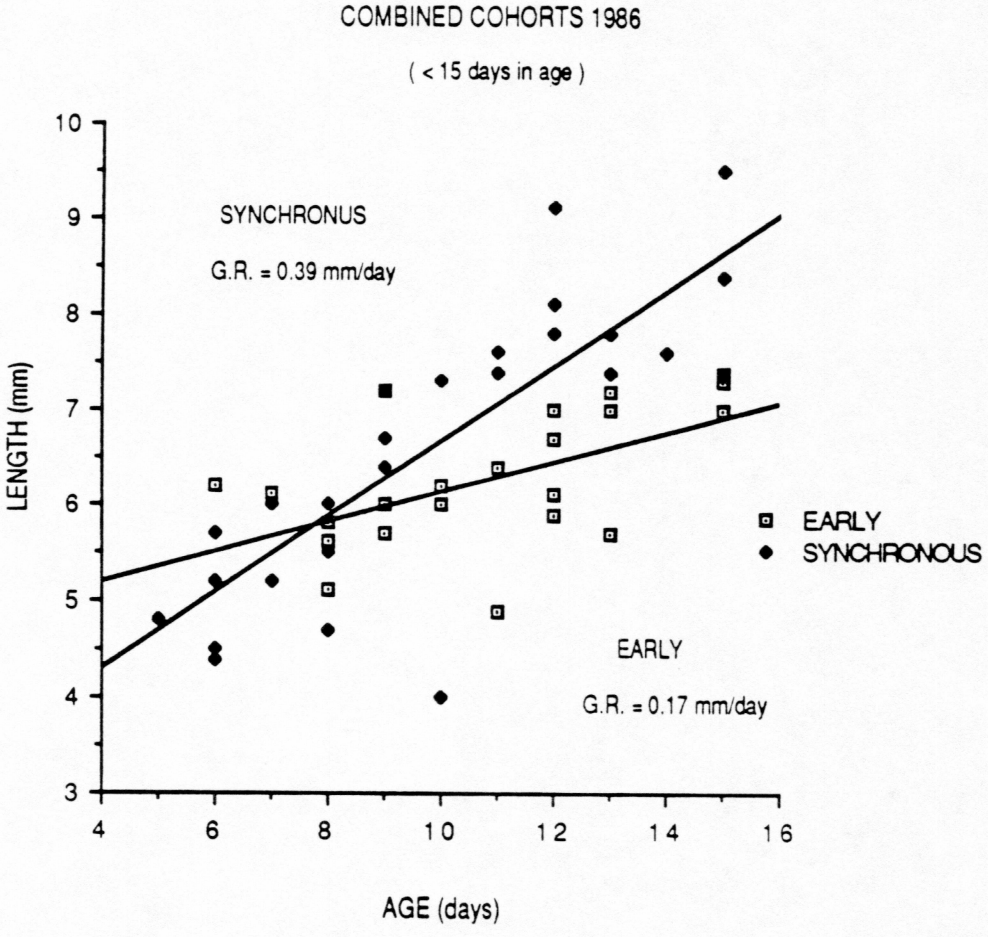
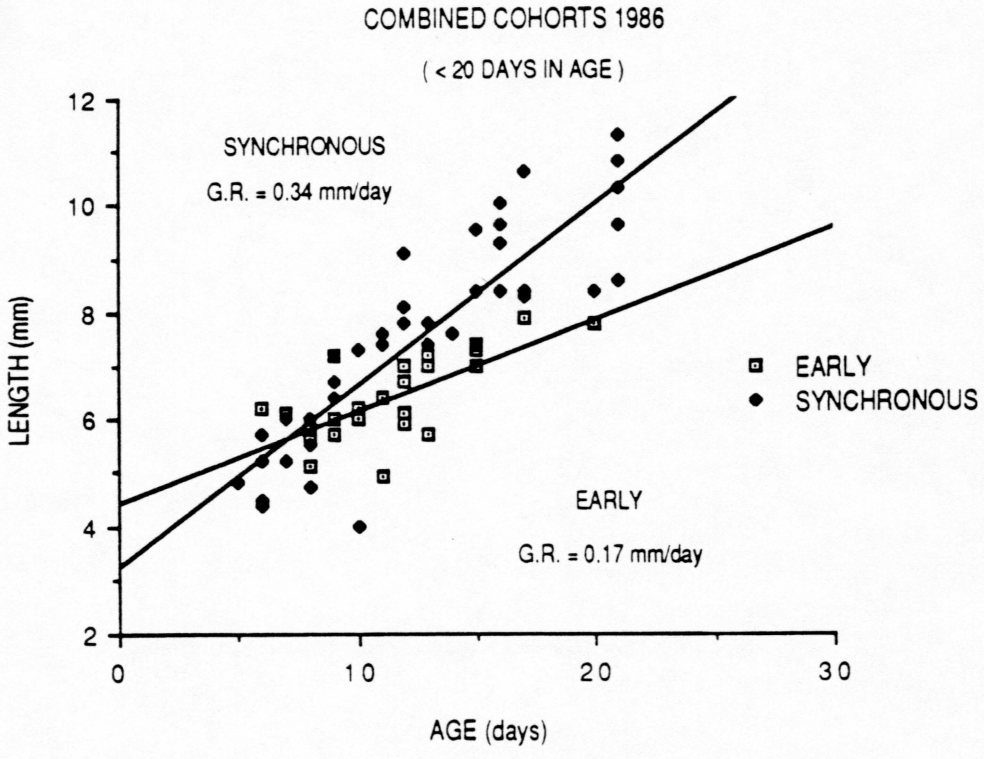

COMBINED COHORTS 1986
(< 15 days in age)
SYNCHRONUS
G.R. = 0.39 mm/day
EARLY
G.R. = 0.17 mm/day
EARLY
SYNCHRONOUS
LENGTH (mm)
AGE (days)
10
9
8
7
6
5
4
3
4
6
8
10
12
14
16

Figure 13. Length-age regressions for the early (hatched April 15-19) and the synchronous (hatched May 10-15) cohorts of larval walleye pollock <20 days in age. G.R.= growth rate. For the early cohort; n=24, R^2=0.50, y=4.41 + 0.1735 x. For the synchronous cohort; n=38, R^2=0.77, y=3.26 + 0.3390 x.


COMBINED COHORTS 1986
(< 20 DAYS IN AGE)
SYNCHRONOUS
G.R. = 0.34 mm/day
EARLY
G.R. = 0.17 mm/day
EARLY
SYNCHRONOUS
LENGTH (mm)
AGE (days)
12
10
8
6
4
2
0
10
20
30

category. The number of pollock larvae present in each length category is indicated by n (Figure 14).

Of the 88 larval pollock guts examined, 91% (80) had food in their guts. The mean number of prey was 3.7 prey items/gut for all larvae in the early cohort. The mean number of prey was 7.0 prey items/gut for the synchronous cohort. There was no significant difference in mean numbers of prey between cohorts for the <5.5 mm and the 5.5-6.9 mm length categories (Figure 15).

Copepod eggs were consumed by all length categories for both feeding cohorts. Pollock larvae in the <5.5 mm length category of the early cohort consumed the highest levels (20%) of copepod eggs (Table 2).

Empty guts were found in the early and synchronous cohorts. For both cohorts empty guts were confined to the length category <5.5 mm; 25% of larvae in the early cohort and 22% of larvae in the synchronous cohort had empty guts. Only those pollock larvae with food in their guts were used for statistical analysis.

Numerically, copepod nauplii were the most common prey item consumed by larval pollock in all larval length categories (Figure 16). Copepod nauplii

Figure 14. Mean length of larval pollock per length category within the early (April 22-May 12) and the synchronous (May 19-June 30) cohorts. n denotes the number of pollock larvae found within each length category.

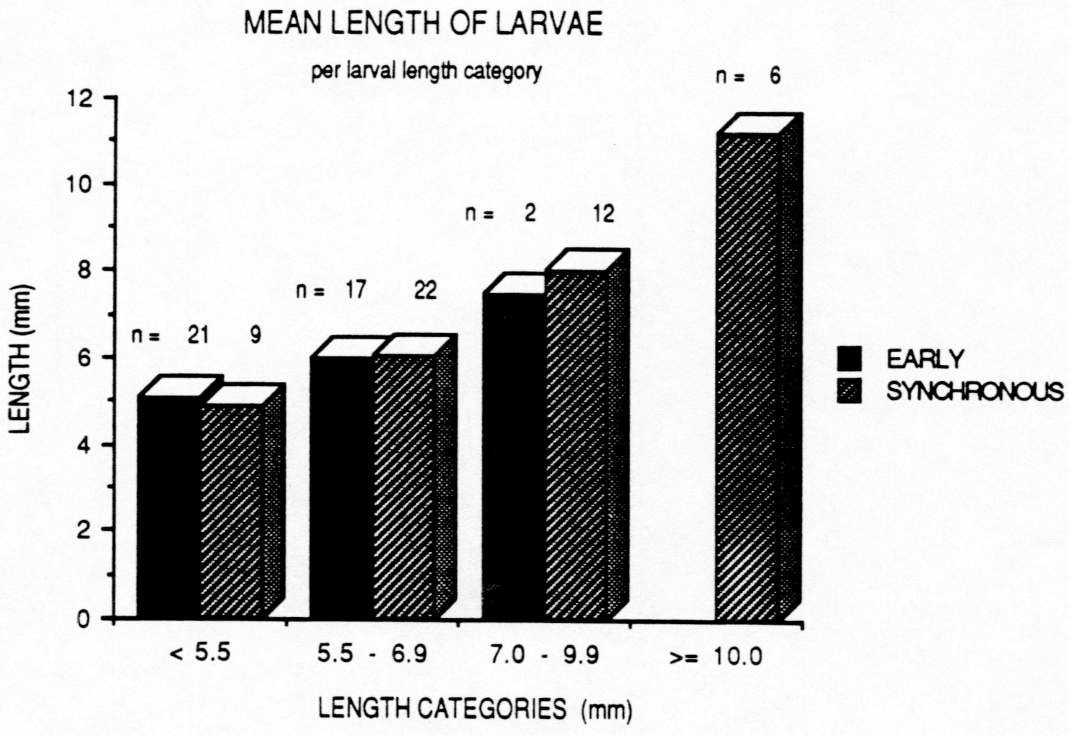

MEAN LENGTH OF LARVAE
per larval length category
LENGTH (mm)
12
10
8
6
4
2
0
n = 21 9
n = 17 22
n = 2 12
n = 6
< 5.5
5.5 - 6.9
7.0 - 9.9
>= 10.0
LENGTH CATEGORIES (mm)
EARLY
SYNCHRONOUS

Figure 15. Mean number of prey per length categories within the early (April 22-May 12) and the synchronous (May 19-June 30) cohorts. Standard error bars show the variance of data around the mean.

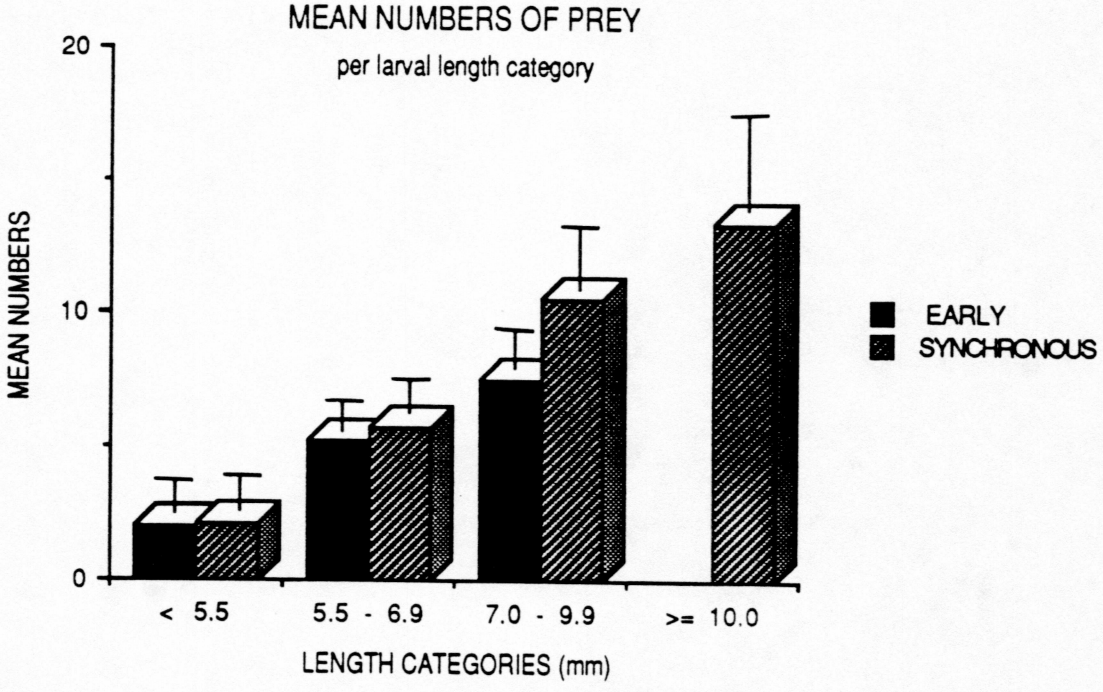

MEAN NUMBERS OF PREY
per larval length category
MEAN NUMBERS
20
10
0
< 5.5
5.5 - 6.9
7.0 - 9.9
>= 10.0
LENGTH CATEGORIES (mm)
EARLY
SYNCHRONOUS

Table 2. Percent number (%N), volume (%V), and frequency of occurrence (%FO) of all prey items consumed by larval pollock in the early cohort (April 22-May 12) for 1986.

	LARVAL LENGTH CATEGORIES								
	<5.5mm			5.5-6.9mm			7.0-10.0mm		
PREY ITEMS	%N	%V	%FO	%N	%V	%FO	%N	%V	%FO
COPEPOD NAUPLII	39	45	40	71	60	71	93	87	100
PSEUDOCALANUS SPECIES	2	3	5	8	6	29			
CHYME	37	45	50	12	15	41			
EUPHAUSID NAUPLII	2	1	5	3	8	18			
BARNACLE NAUPLII				2	5	12			
COPEPOD EGGS	20	6	25	2	1	12	7	13	50
UNIDENTIFIED EGGS				1	5	6			

Figure 16. Percent number of all prey items consumed by larval pollock in the early cohort (April 22-May 12) and the synchronous cohort (May 19-June 30) for 1986.